Wastewater Treatment and Reclaimed Water Reuse in Arizona: Past and Present

by

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Flagstaff, AZ
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Wastewater Treatment

- Haven't determined when the first sewage treatment plant in Arizona was built, but…

  - In mid-Dec. 1899, Flagstaff accepted construction of 1.7 miles of sewer line

  - at a cost of $8500!

Plans Established To Build A Sewer

SUNfiles, Dec. 30, 1899

The Flagstaff Drainage and Improvement Company was organized in August last and the contract for the construction of the sewer let to Messrs. Cornish and McWilliams, who began work in September. The work was practically completed the latter part of November and the work accepted by the company on December 19.

The system consists of 4,507 feet of 12-inch main, 1,744 feet of eight-inch main, 266 feet of six-inch main, 525 feet of eight-inch lateral and 1,797 feet of six-inch lateral, salt glazed, vitrified sewer pipe. There are 27 man holes, eight lamp holes and four Miller automatic flush tanks.

The officers of the company are J. Aubineau, president; D. J. Brannen, vice-president; T. J. Coalter, secretary; George Babbitt, treasurer; directors, J. Aubineau, D. J. Brannen, J. A. Vail, J. J. Donahue and E. S. Gosney.

It is not the intention of the company to make a profit for the sewerage service and their rates are very low for the use of the system. The cost of the system was nearly $8,500.

The Sun, Flagstaff, December 30, 1899

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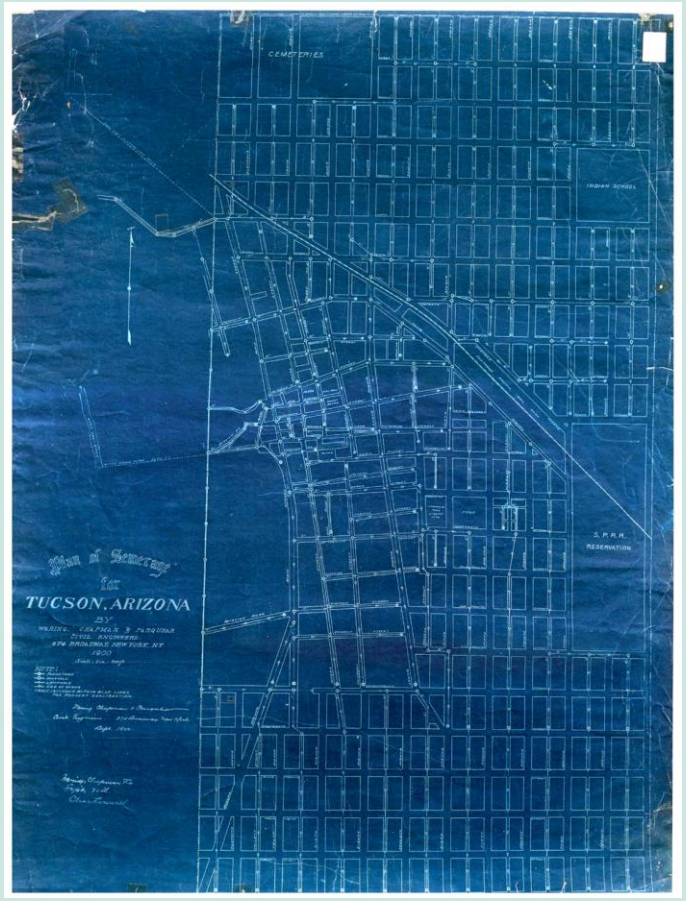
Wastewater Treatment

- Plan for Tucson sewer construction on the books in 1900
- In 1931, Phoenix constructs 15 million gallon per day (mgd) sewage treatment plant
  - secondary treatment
  - chlorine disinfection of effluent

Arizona Sewage Works Association members at Phoenix plant, 1937



Plan of Sewerage for Tucson, Arizona, 1900

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Wastewater Treatment

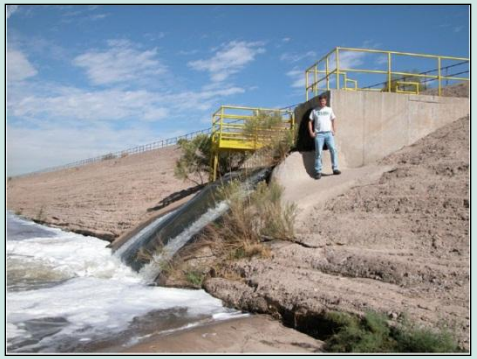
- Primary treatment – physical processes
  - screening and settling to remove particulate matter

- Secondary treatment – biological processes
  - microbial degradation of organic wastewater constituents
  - usually followed by settling, gravity filtration, and disinfection

- Tertiary treatment – advanced treatment processes
  - chemical treatment including advanced oxidation processes (AOP), pressure filtration such as RO, and/or other technologies
  - usually targets pollutants or classes of pollutants that require more complete removal than provided by primary & secondary treatment

Management Options for WWTPs

- Surface water courses
  - discharge to dry streambeds, streams, rivers, lakes, reservoirs
  - most common method



Roger Road WWTP Outfall into Santa Cruz River, Tucson (USGS photo)

- Infiltration
  - basins (rapid infiltration basins or RIBs) – tend to be smaller facilities
  - trenches and beds – generally very small facilities

Infiltration basin, Glendale, AZ

Management Options for WWTPs

- Recharge (i.e., managed infiltration)
  - not considered or regulated as "disposal"
  - a significant practice, usually in ADWR Active Management Areas (AMAs), to reduce groundwater overpumping
  - ADWR gives credits in AMAs that offset limits on groundwater pumping

Ft. Huachuca recharge pond

- Reuse (more on this in a moment)
  - not considered or regulated as "disposal"

Wheeling reclaimed water around, Gilbert Riparian Preserve

"It doesn't go off the planet, so it has to go somewhere."
-Anonymous

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Clean Water Act—A Major Step Forward

- The 1972 CWA requires all major facilities discharging to a surface watercourse to obtain a NPDES permit
  - NPDES: National Pollutant Discharge Elimination System
- EPA delegates permit issuance to ADEQ
  - called an AZPDES Permit in Arizona
- ADEQ has issued AZPDES permits to ~125 WWTPs in AZ
  - 75% of all AZPDES permits are for WWTPs
  - Other 25% are for power plants, mines, other industrial & miscellaneous discharges
- In the past, NPDES generally has required only secondary treatment for WWTPs

Clean Water Act and Flagstaff WWTPs

- NPDES permittees must meet SWQS established for the designated use(s) of the water into which the discharge occurs
- In 1987, the Rio de Flag was designated an "Effluent Dependent Water"
  - i.e., a water, which otherwise would be ephemeral, created by the discharge
- SWQS limits for the Rio de Flag include
  - E. coli – 126 cfu / 100 ml
  - Nitrate/nitrite – no requirement (i.e., no upper limit)
- In 2009, after plant upgrades, ADEQ issued new AZPDES permits for discharge into the Rio de Flag by:
  - Rio de Flag WWTP (4 mgd)
  - Wildcat Hill WWTP (6 mgd)

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APP – Another Major Safeguard

- The Aquifer Protection Permit Program is an Arizona-unique program to protect groundwater quality

- Any person with a discharge that will, in reasonable probability, reach an aquifer must obtain an APP

- In 2001, ADEQ set stringent APP technology standards for WWTPs (Best Available Demonstrated Control Technology or BADCT)

- All new & expanding WWTPs must employ high-performance, tertiary treatment

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APP BADCT for WWTPs

- All new or expanding WWTPs with a design capacity of more than 0.25 mgd must achieve:
  - Pathogen-free effluent
    - Routinely no detectable *E. coli*
  - Nitrogen removal to below the 10 mg/l DW standard
    - WWTPs normally produce 45 – 70 mg/l
  - Non-turbid discharge (using filtration)*
    - ≤ 2 NTU (24-hr average; never to exceed 5 NTU)
  - Odor control
- Both Flagstaff plants have been upgraded & meet new facility BADCT

Advanced treatment & odor control at Gilbert Neely WWTP

*Required for Class A+ rating for reuse

Reclaimed Water Use in Arizona

- 90% of reuse occurs in just four states, Arizona being one

Source: Western Water, July/August 2008

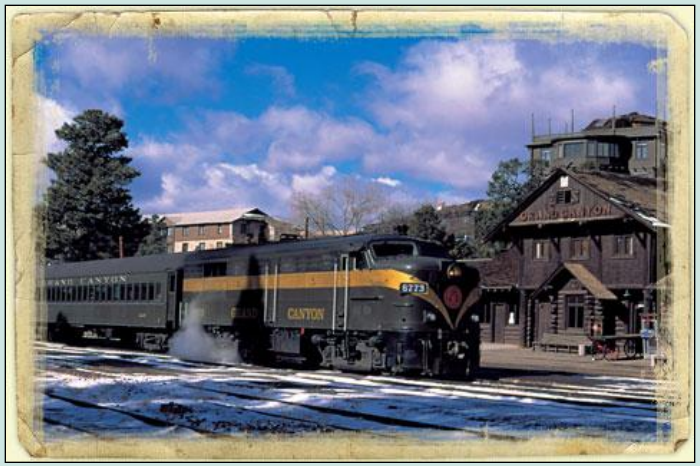
Why Arizona?

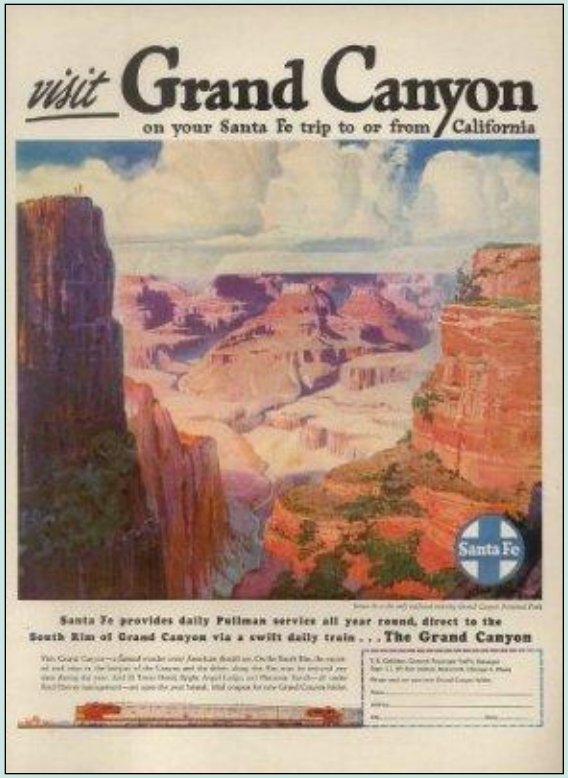
- Driven by need
- Comprehensive legal framework

Driven by Need for Water

Arizona was one of the first states to reuse treated wastewater

- Grand Canyon Village – 1926
  - Toilet flushing
  - Boiler feed for power generation
  - Water for steam locomotives



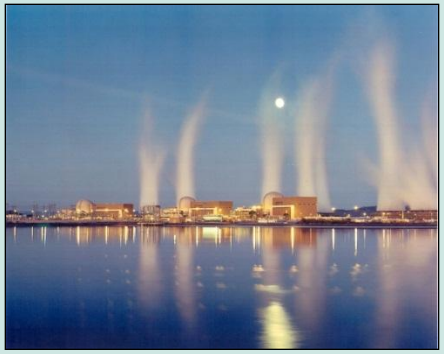


Driven by Need for Water

Later milestones for reuse of treated wastewater

- Phoenix 23rd Avenue WWTP – 1932
  - Agriculture
- 1st reclaimed water rules, ADHS – Jan 1972
- Phoenix 91st Avenue WWTP – 1983
  - Delivery to Palo Verde Nuclear Generating Station

Phoenix 91st Ave WWTP



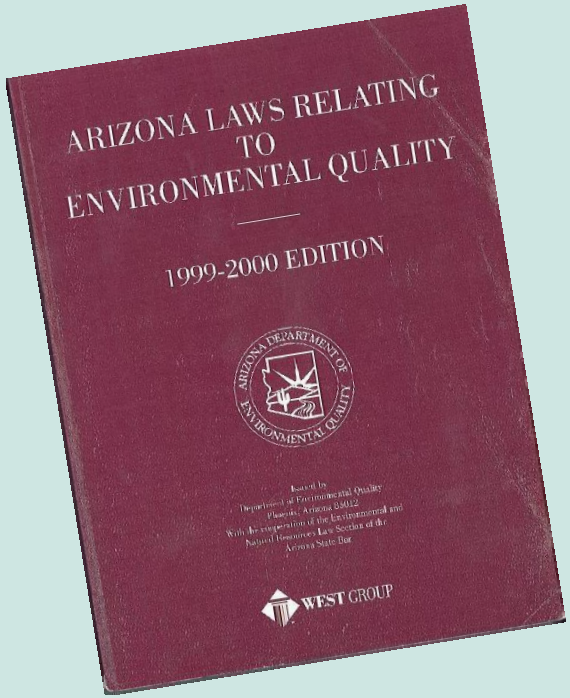
APS Palo Verde Nuclear Generating Station

Driven by Need for Water

- First full-scale engineered recharge project involving reclaimed water began operating in 1989
  - Tucson Sweetwater Recharge Facility

Comprehensive Regulatory Framework

- Clear legislative authority granted to ADEQ in 1999
  - Reclaimed water quality standards
  - Permit program for the direct reuse of reclaimed water
  - Technical standards for open channel and pipeline conveyances



Comprehensive Regulatory Framework

- ADEQ completely transformed its reclaimed water rules, becoming effective Jan. 16, 2001
  - Fosters reuse while protecting water quality and human health
  - Aquifer Protection Permit (APP)—reclaimed water quality is controlled at & responsibility of the WWTP
  - Reclaimed Water Permit (RWP)—regulates use and application by the end user
  - Reclaimed WQS—5 classes of reclaimed water established: A+, A, B+, B, C

Photo: Southwest Hydrology, Jan/Feb 2010

Comprehensive Legal Framework

- By court decision, WWTPs own their treated wastewater and have direct control over disposal or distribution for reuse
- For WWTPs intending to distribute water for reuse, ADEQ indicates the applicable RWQS class in the plant's APP
  - WWTP must monitor to ensure that the RWQS are met
- ADEQ has adopted technical standards for open channel and pipeline ("purple pipe") conveyances
- ADEQ issues Reclaimed Water Permits for end use
  - O&M is relatively straightforward because water quality is maintained by the WWTP under its APP
- ADEQ has established allowed end uses for each RWQS class

City of Tucson

Class C Reclaimed Water

- Little chance of contact by general public
- Allowed uses include:
  - pasture for non-dairy animals
  - livestock watering (non-dairy animals)
  - irrigation of sod farms
  - irrigation of fiber, seed, forage & similar crops
  - silviculture

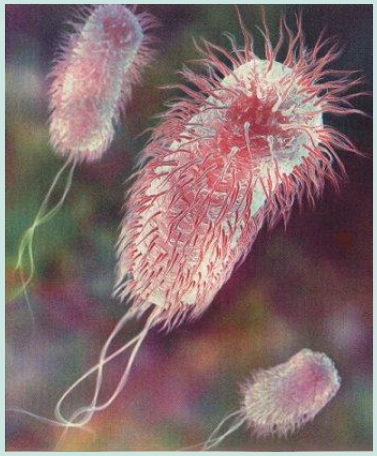
Class C Reclaimed Water Limits and Monitoring

- Total retention time in wastewater stabilization ponds: ≥ 20 days

- Fecal coliform (cfu/100 ml): < 1000* (4 of last 7 samples)

  < 4000 (single sample maximum)

* 99.9% - 99.999% removal compared to raw sewage



E. coli bacteria

Class B Reclaimed Water

- For *restricted access* uses (access by general public is controlled)
- Some Class B uses allowed in rule
  - surface irrigation of an orchard or vineyard
  - golf course irrigation
  - restricted access landscape irrigation
  - landscape impoundment
  - dust control
  - pasture for milking animals
  - livestock watering
  - concrete mixing

El Conquistador Golf Course, Oro Valley

Class B Reclaimed Water Limits and Monitoring

- Fecal coliform (cfu/100 ml): < 200 (4 of last 7 daily samples)

  < 800 (single sample maximum)

  Compare to ADEQ Surface WQS for E. coli for "partial-body contact":

  < 126 (geometric mean of last 4 samples)

  < 575 (single sample maximum)

- To gain Class B+ rating: Nitrogen removed to below 10 mg/l

Class A Reclaimed Water

- For *open access* uses (access by general public is uncontrolled)
- Some Class A uses allowed in rule

  - irrigation of food crops
  - recreational impoundments
  - residential/schoolyard landscape irrigation
  - other open access landscape irrigation
  - toilet & urinal flushing
  - fire protection systems
  - spray irrigation of an orchard or vineyard
  - snowmaking

Northern Arizona University

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Class A Reclaimed Water Limits and Monitoring

- Turbidity (by filtration): ≤ 2 NTU (24-hr average)

  ≤ 5 NTU (never to exceed)

- Fecal coliform: No detectable (4 of last 7 daily samples)

  < 23 cfu/100 ml (single sample maximum)

  Compare to ADEQ Surface WQS for E. coli for "full-body contact":

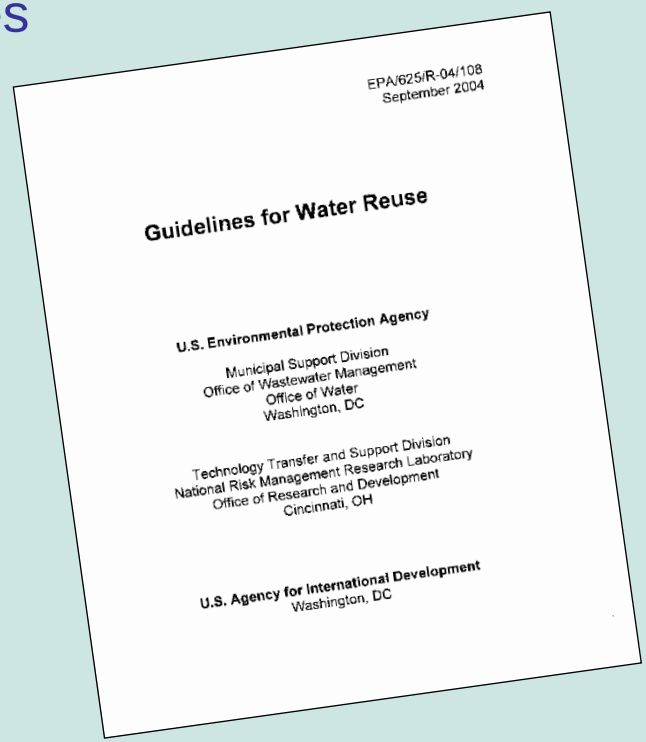
  < 126 cfu/100 ml (geometric mean of last 4 samples)

  < 235 cfu/100 ml (single sample maximum)

- To gain Class A+ rating: Nitrogen removed to below 10 mg/l

Reclaimed Water Quality vs. Canal Water Quality

- For 2001 rule, ADEQ relied heavily on 1996 EPA Reuse Manual for standards and allowed uses
- ADEQ also reviewed Salt River Project canal sampling records
- SRP had collected 61 fecal coliform (FC) samples throughout canal system
  - Highest (cfu/100 ml) > 16,000
  - Mean = 2360
  - Median = 500
  - Lowest = 17
- Compare to RWQS
  - Class A = 0
  - Class B = 200
  - Class C = 1000


EPA/625/R-04/108
September 2004

Guidelines for Water Reuse

U.S. Environmental Protection Agency

Municipal Support Division
Office of Wastewater Management
Office of Water
Washington, DC

Technology Transfer and Support Division
National Risk Management Research Laboratory
Office of Research and Development
Cincinnati, OH

U.S. Agency for International Development
Washington, DC

Reclaimed Water Quality vs. Canal Water Quality

- SRP collected 300 turbidity samples at South Canal & intake to Val Vista Drinking Water Treatment Plant
  - Highest (NTU) = 500
  - Mean = 34
  - Median = 14
  - Lowest = 6 (twice)
- Class A, A+ standard
  = 2 (24-hr avg)
  = 5 (never to exceed)
- SRP canal water has irrigated residential yards, parks & schoolyards since 1928

SRP Residential Irrigation, Phoenix

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Reclaimed Water Permits

- ADEQ issues Reclaimed Water Permits to ensure the safe end use of reclaimed water

- ADEQ issues two types of permits for end use
  1. A single end user permit
  2. A reclaimed water agent permit for an entity that assumes responsibility for multiple end users of reclaimed water

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Single End User Permits

- Permits available for all 5 classes of reclaimed water—A+, A, B+, B, C
- Allows permit holder (say a farmer) to receive reclaimed water from a WWTP authorized by its APP to distribute water of that class
  - however, WWTP always has control over whether it wishes to supply a permit holder
- Permit holder must comply with O&M, signage, and other requirements of the permit
- Permit holder must keep records and report volumes, areas of use, and other information to ADEQ
- Relatively uncomplicated requirements for A+ and B+ permits because supplied water meets drinking water standard for nitrogen

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Reclaimed Water Agent Permit

- Agent is responsible for the reuse of reclaimed water by all the end users it acts as agent for
- Agent must have a contract with each end user
  - contract must specify any end user signage or other obligations
- Agent keeps records and reports to ADEQ rather than end user
- Agent is the compliance/enforcement entity of record for ADEQ
- Agent controls who it wishes to contract with & which end uses it wishes to supply

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Reclaimed Water Agent Permits

- ADEQ has issued 47 agent permits to date representing several thousand residential, municipal & industrial, and agricultural users
- Top 6 agent permits (based on number of end users)
  - City of Tucson
    - 18 golf courses
    - 39 parks
    - 52 schools (incl. University of Arizona)
    - more than 700 single family homes
  - Lake Havasu City
  - City of Flagstaff
    - 60 reuse sites listed in latest agent report to ADEQ
  - City of Cottonwood
  - Anthem
  - Arrowhead Ranch, Glendale

Irrigating athletic field with reclaimed water, University of Arizona

Reclaimed water pumps, City of Flagstaff

How Has ADEQ's Program Worked?: Arizona's 12 Largest WWTPs

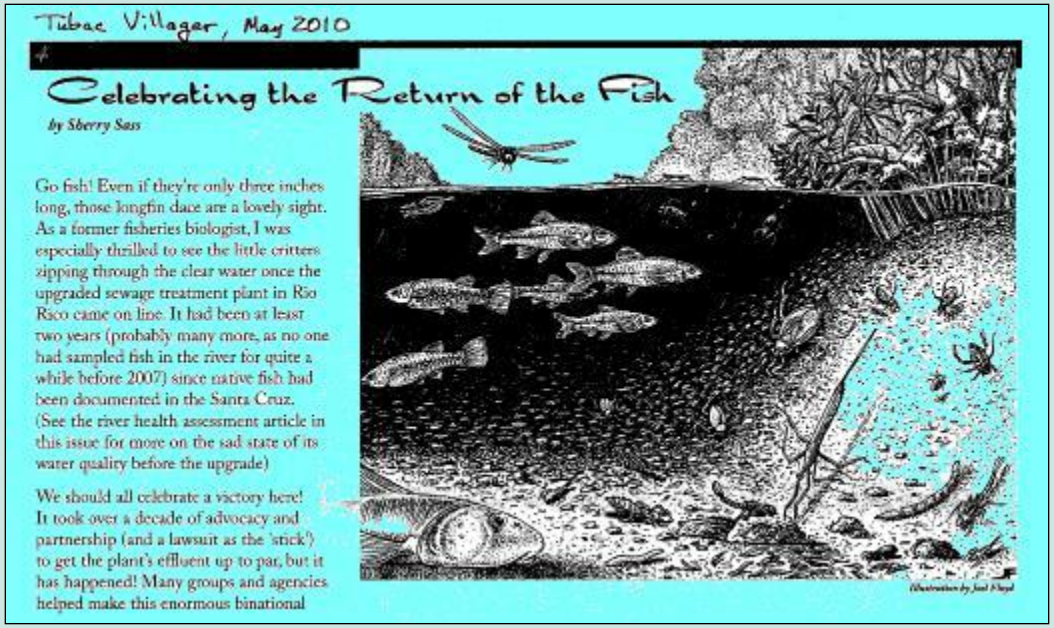
WWTP	Design Flow (mgd)	Reuse?	RWQS Class	Comment
1. Phoenix 91st Avenue	204.5	Yes	B+	60-70 mgd to PVNGS; much to agric.
2. Phoenix 23rd Avenue	63	Yes	B+	
3. Pima County Roger Rd	41	Yes	B	
4. Pima County Ina Road	37.5	Yes	B	New (A+) & old treat. trains combined
5. Mesa Greenfield	24	Yes	A+	
6. Scottsdale Water Campus	23.6	Yes	A+	Includes managed recharge facility
7. Mesa Northwest	18	Yes	A+	Includes managed recharge facility
8. Tolleson	17.5	Yes	B	

How Has ADEQ's Program Worked?: Arizona's 12 Largest WWTPs

WWTP	Design Flow (mgd)	Reuse?	RWQS Class	Comment
9. Nogales International	17.2	No	Not classed	But new plant meets A+
10. Surprise South	16.3	Yes	A+	
11. Chandler Airport	15	Yes	A+	
12. Yuma	12	No	Not classed	Discharges to Colorado River
Flagstaff Wildcat Hill	6	Yes	A+	
Flagstaff Rio de Flag	4	Yes	A+	

How Has ADEQ's Program Worked? "Celebrating the Return of the Fish"

- In 2009, the Nogales International WWTP was finally upgraded from sub-C to A+ class treatment
- In 2 yrs, the downstream Santa Cruz River went from long dead to clear and live with native fish



Tubac Villager, May 2010

Celebrating the Return of the Fish

by Sherry Sass

Go fish! Even if they're only three inches long, those longfin dace are a lovely sight. As a former fisheries biologist, I was especially thrilled to see the little critters zipping through the clear water once the upgraded sewage treatment plant in Rio Rico came on line. It had been at least two years (probably many more, as no one had sampled fish in the river for quite a while before 2007) since native fish had been documented in the Santa Cruz. (See the river health assessment article in this issue for more on the sad state of its water quality before the upgrade)

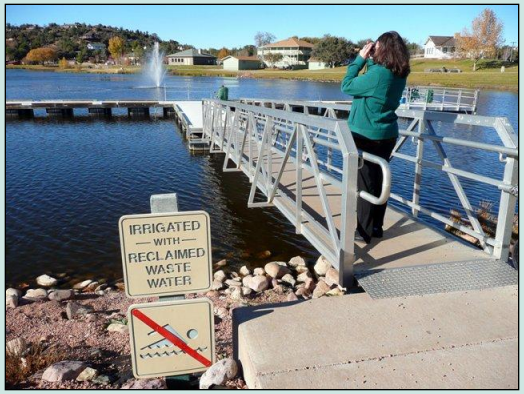
We should all celebrate a victory here! It took over a decade of advocacy and partnership (and a lawsuit as the 'stick') to get the plant's effluent up to par, but it has happened! Many groups and agencies helped make this enormous binational

Impact of Comprehensive Legal Framework

- High-quality wastewater is produced, which allows safe reclaimed use by end users

Pumping Reclaimed Water,
Surprise, AZ

- *Result:* High-performance treatment, balanced with appropriate end-use requirements, has turned once poor-quality wastewater "to be gotten rid of" into a resource



Town of Payson Green Valley Lake

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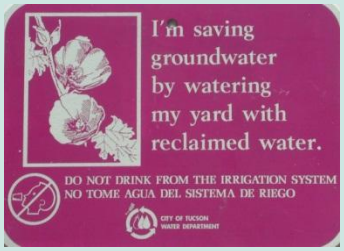
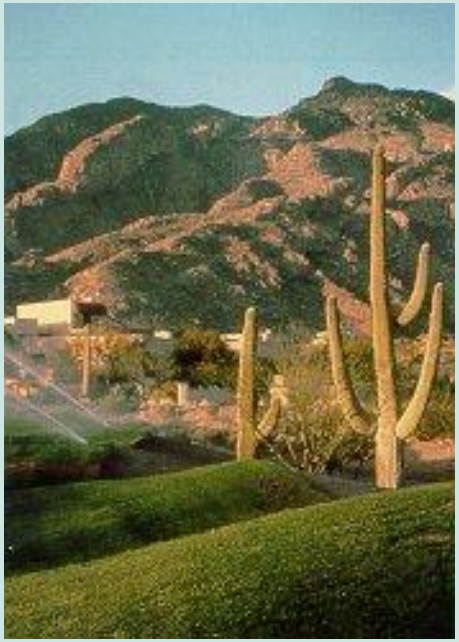
Arizona's Reclaimed Water Program: The Current Story



- 65% of sewage treatment plants in AZ now distribute treated wastewater for reuse (203 WWTPs)
- 340 single end user permits issued

- 47 agent permits issued to date
- 10 of the 12 largest WWTPs in AZ now distribute high-quality treated wastewater for reuse



Tucson golf course irrigated by reclaimed water

Rapid Transition to High-Performance Treatment

- Current individual end user permits by reclaimed water class

A+	72%
A	2%
B+	13%
B	9%
C	3%

Freestone Park, Gilbert

Sun Lakes, Maricopa County

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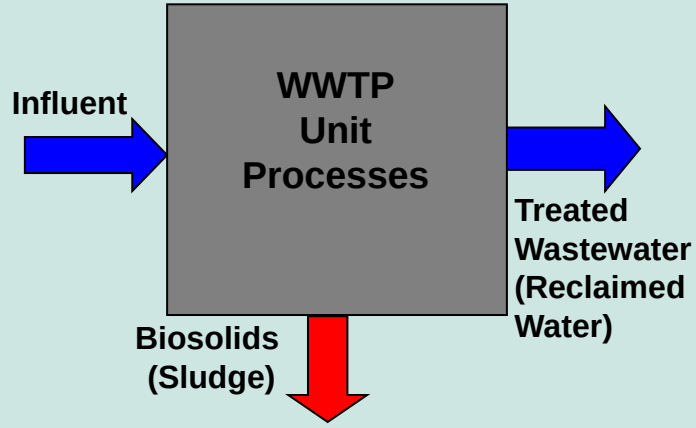
Contaminants of Emerging Concern (CECs)

- Reuse of treated wastewater is a significant part of the AZ water budget
- 2001 rules were developed to ensure safety from pathogens & protect groundwater from nitrogen contamination
  - CECs were not yet on the horizon
- Much CEC research now by all 3 Arizona state universities
  - occurrence and fate
  - human health and aquatic impacts
  - enhancing removal in WWTPs



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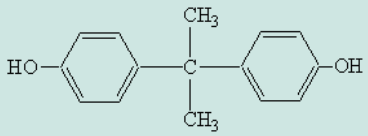
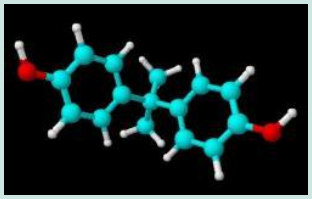
Contaminants of Emerging Concern (CECs)

- Too little is known yet to set human health numeric standards for most CECs, but risk so far looks minimal
- EPA recently released its Contaminant Candidate List 3 (CCL3) for drinking water
  - includes a dozen or so CECs of interest to reclaimed water use
  - requires monitoring for occurrence and concentration levels in US public drinking water systems
  - results, along with toxicological and other studies, will be used to establish numeric drinking water standards, if merited
- ADEQ will review RWQS if EPA or other scientific studies indicate that casual exposure to reclaimed water may pose a human health threat



Bis-phenol A



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However, The Good News

- Unlike most states, AZ mandates high-performance treatment with nitrogen removal in all new & expanding WWTPs
- Corollary benefit: this treatment also greatly reduces CEC levels
  - Nitrogen removal allows attack by a range of bacteria in the successive anoxic and oxic unit processes
  - Longer residence time for nitrogen removal also aids the bacteria in their degradation of CECs
- Work by UA & others shows high CEC removal rates
  - Secondary treatment: 20-40%
  - Tertiary treatment with N-removal: 60-99%
- Overall, AZ is in much better shape than most other states in removing CECs from treated wastewater
- Recent Governor's Blue Ribbon Panel on Water Sustainability recommends accelerating research on CECs in reclaimed water

More Information

More information on ADEQ's reclaimed water program and water quality information generally is at: www.azdeq.gov.

Governor's Blue Ribbon Panel Report is available at: www.azwater.gov.

ADEQ Main Office, Phoenix